TIP 46: Transmission System Operations - Study Process Automation

Context

Today's transmission system is stressed by increasing use and changing markets. Examples include the following:

- Wind generation on the BPA system exceeded 3000 MW in 2010, exceeded 4500 MW in 2013 and is expected to be 6,000-7,500 MW by 2016.
- Power system maintenance work has been compressed into just a few months so that market impacts can be minimized while continuing to avoid critical operational periods.
- Energy transfers continue to increase as power is bought and sold across the entire West Coast to meet load and renewable clean-energy mandates.

Since the 1996 blackouts, BPA has performed daily outage studies. These studies directly impact the access to BPA transmission that private utilities, public utilities, independent power producers, and wind generators depend on to buy and sell power throughout the Northwest. The tools used by engineers require extensive set-up time to represent operating conditions and can take up to 24 hours of compute time to produce results.

During a real-time event, operating limits are reduced to a conservative level while changing system conditions are analyzed. The time it takes to develop new operating limits delays the customer's ability to resume access to the transmission system. The future grid must be able to perform real-time analysis, identify new reliability risks, and set new System Operating Limits (SOLs) for real-time operations within 0-30 minutes of an event.

This project provides regional benefits by enabling BPA to use the capability of the transmission system more effectively, while more responsively analyzing the reliability impacts of continuously changing system conditions.

Description

The System Operations Study Automation Project builds on current analysis tools to enhance the following functions:

- Improve compute and analysis speed
- Use real measurements as the starting point for studies to add accuracy and reliability
- Contingency screening studies
- Voltage stability studies including PV (power vs. voltage) and QV (VAR vs. voltage).
- Transient Stability Studies

This project develops future technologies to address real-time system outages and changing conditions by being able to quickly generate reliable system limits that accurately reflect system operating configurations and creating corresponding system operating limits.

The first phase of this project focused on increasing power flow computer performance by funding development of distributed computing power flow study software. This effort changed the power flow software to run in a distributed environment on several CPUs simultaneously and shorten the elapsed time to perform study calculations. Several unplanned power system outages were studied in near real time using the distributed processing software; study engineers were able to obtain results 6-10 times faster than achieved using current software.

Why It Matters

Keeping the lights on (reliability) and keeping BPA customer costs low (money) are the keys. The Transmission Operations study team performs studies that simulate planned transmission system outage conditions and set SOLs. Accurate system models and high-performance tools provide engineers with the ability to ensure reliability while quickly restoring customer access to transmission.

Goals and Objectives

The objectives of the Study Automation Project are to improve daily SOL power flow studies to accomplish the following tasks:

1. Reduce the elapsed time to prepare a new SOL after an unplanned line outage(s) by reducing preparation time and computation time for power flow studies from about 6 hours to under 1 hour.
2. Use actual measurements from the power system as the starting point for a study to improve accuracy rather than seasonal base cases prepared months earlier.
3. Prepare a real-time power flow base case after a disturbance within 10 minutes, compared to a few months with current methodologies.
4. Reduce workload of System Operations study engineers and improve study quality.
5. Use real-time data to optimize transmission capacity congruent with reliability.

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Project Start Date: October 1, 2007

Project End Date: September 30, 2014

Reports & References

WOCN Lesson Learned Recommendation #3
Executive Summary

Internal Whitepapers

1. *Real-Time Model Study Process Automation*, B. Tuck, R. Ramanathan, T. Doern, 2011.
2. *Distributed Computing Study Process Automation*, B. Tuck, R. Ramanathan, T. Doern, 2011.
3. Full Topology Voltage Stability Analysis - Study Process Automation, B. Tuck, R. Ramanathan, T. Doern, 2011.
4. *Algorithm Improvements Study Process Automation*, B. Tuck, R. Ramanathan, T. Doern, 2011.
5. *Transient Stability Benchmarking: Transient Security Assessment Tool (TSAT) vs. PowerWorld*, Ran Xu, 2010.

Conference Papers

6. *Application of Advanced Computing Methods to Transmission System Operational Studies at the Bonneville Power Administration*, B. Tuck, R. Ramanathan, T. Doern, IFAC 2012
7. *BPA's Experience of Implementing Remedial Action Schemes in Power Flow for Operation Studies*, R. Ramanathan, B. Tuck, J. O'Brien, Accepted for IEEE Power & Energy Society (PES) 2013.

Participating Organizations

Maxisys, Inc.
PowerWorld, Inc.

Funding

Total Project Cost:	$1,738,431
BPA Share:	$1,738,431
External Share:	None
BPA FY2013 Budget:	$450,000

Key Results/Conclusions

- Implemented distributed processing to use multiple CPUs to speed up system operating limit studies by up to 1000%.
- Improved the software efficiency of the automated system operating limit studies adding an additional 600% speed improvement.
- State estimator and custom software automatically generates over 100 cases a day.
- State estimator based studies use real measurements for more accurate system studies.
- Implemented a power circuit breaker oriented power flow model to find hidden problems.
- A sample cost savings during unplanned line outage events impacting the northern intertie path (±$665K) and west of Cascades north path (±$793K).

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